A Low-Cost Microstrip Antenna for Wireless FidelityApplication

Antenna and Microwave Components

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Abstract

In this paper, an attempt has been made to design a new microstrip-fed monopole antenna for wireless fidelity (Wi-Fi) systems. The proposed antenna is fabricated on the FR4 substrate with dielectric constant of 4.4. By cutting a pair of inverted L-shaped slits in the square radiating patch, a new resonance at lower frequency (2.4GHz) can be achieved, also by inserting two L-shaped slits in the ground plane, the antenna achieves good dual-band operation. The measured impedance bandwidth for l0 dB return loss is from 2.05 GHz to 2.76 GHz (29.9%) and 4.6 GHz to 5.46 GHz (17.0%), covering the 2.4 and 5.2 GHz wireless fidelity operating bands. Simulated and experimental results obtained for this antenna show that the proposed monopole antenna has a good antenna gains and radiation behavior, with a small dimension of 12×18 mm².

Keywords

Dual Band; Wireless Fidelity; L-Shaped Slit; Monopole Antenna.

Introduction

Wireless communications have been developed widely and rapidly in the modern world especially during the last decade. In many applications of wireless communications such as Personal Communications Services (PCS), Bluetooth, IEEE 802.11 Wireless Local Area Networks (WLAN, e.g. Wi-Fi i.e. IEEE 802.11a, 802.11b, 802.11g, 802.11j etc.), it is desirable to use multi-band antennas that are small in size. One type of wireless communications is Wireless Fidelity (Wi-Fi). A Wi-Fi enabled device such as a personal computer, video game console, smart phone or digital audio player can connect to the Internet within range of a wireless network connected to the Internet. One method to obtain multi-band operation is a shorted T-shaped monopole antenna with antenna gain that is about 2.0-2.6 and 3.2-3.7 dBi for the 2.4 and 5 GHz band respectively. Printed dual band monopole antenna provides two operating frequency bands for Wi-Fi operation with near about 3 and 5.5 dBi gains at frequency 2.4 and 5.8 GHz respectively. If the monopole antenna is designed in ring shaped or hook shaped, the gain is not over 2.8 and 4.29 dBi at frequency 2.4 and 5 GHz respectively.

In this paper, a novel design of a dual-band monopole antenna is proposed which has many advantages such as low-cost, wide bandwidth and easy simple structure. Pair of inverted L-shaped slits in the radiating patch is embedded in order to achieve a new resonance at 2.4 GHz, and also a pair of L-shaped slits has been cut in the ground plane that with this design a good dual-bad function can be achieved. Desirable return loss and radiation pattern characteristics are obtained in the frequency band of interest.

Antenna Design

The proposed monopole antenna fed by a microstrip line is shown in Fig 1, which is printed on a FR4 substrate with the thickness 0.8 mm. As shown in Fig. 1, the proposed antenna consists of a square radiating patch with two inverted L-shaped slits and a modified ground plane with two L-shaped slits. The square patch has a width of W. The patch is connected to a feed line with the width of W_f and the length of L_f. On the other side of the substrate, a conducting ground plane with width W_{sub} and length L_{gnd} is placed. The width W_f of the microstrip feed line is fixed at 1.5 mm. The proposed antenna is connected to a 50Ω SMA connector for signal transmission.

The optimized values of proposed antenna design parameters are as follows: $W_{sub}=12mm$, $L_{sub}=18mm$, $h_{sub}=0.8mm$, $W_f=1.5mm$, $L_f=7mm$, $W=10mm$, $L=10mm$, $W_1=3mm$, $L_1=7mm$, $W_2=2.5mm$, $L_2=0.5mm$, $W_S=3.75mm$, $L_S=3mm$, $W_{S1}=4.25mm$, $L_{S1}=0.5mm$, and $L_{gnd}=4mm$

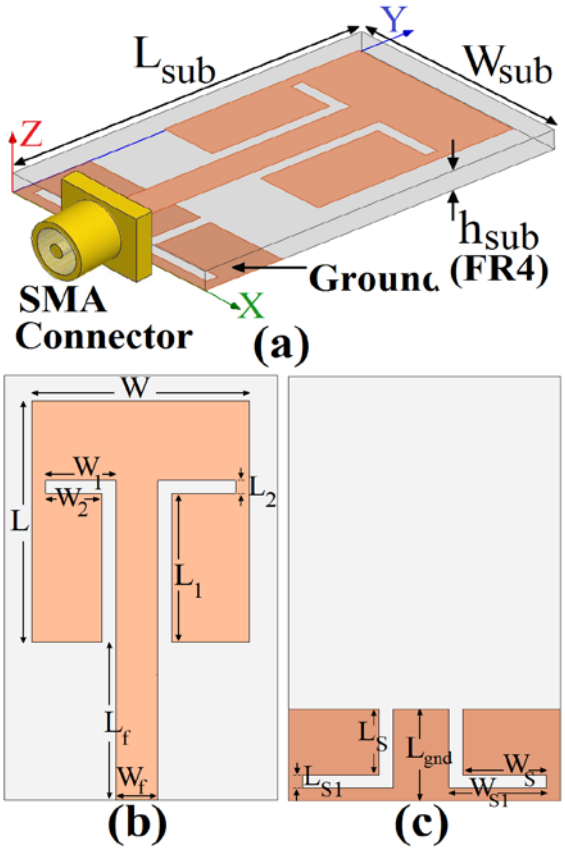

FIG.1. GEOMETRY OF THE PROPOSED MONOPOLE ANTENNA (A) SIDE VIEW, (B) TOP LAYER VIEW, AND (C) BOTTOM LAYER.

Results and Discussions

The proposed monopole antenna with various design parameters has been constructed, and the numerical and experimental results of the input impedance and radiation characteristics are presented and discussed. Ansoft simulation software, high-frequency structure simulator (HFSS) is used to optimize the design of the proposed antenna configuration.

The configuration of the presented monopole antenna is shown in Fig .1. Return loss characteristics for the ordinary square radiating patch antenna with a pair of inverted L-shaped slits (Fig. 2(a)), the proposed antenna structure (simulated) (Fig. 2(b)) and the proposed antenna structure (measured) (Fig. 2(c)) are compared in Fig 3from which it is observed that the lower frequency bandwidth is affected by using a pair of inverted L-shaped slits in the radiating patch and generation of dual-band performance is sensitive to the pair of L-shaped slits in the ground plane. Also input impedance of the proposed antenna structure shown in Fig. 1, on a Smith Chart is shown in Fig. 4.

In order to understand the phenomenon behind this dual-band performance, the simulated current distributions for the proposed antenna on the radiating patch at 2.4 GHz are presented in Fig.5 (a). It can be observed in Fig. 5 (a) that the current concentrated on the edges of the interior and exterior of the inverted L-shaped slits. Therefore, the antenna impedance changes at this frequency due to the resonant properties of the inverted L-shaped slits. Another important design parameter of this structure is the pair of L-shaped slits used in the ground plane. Fig. 5 (b) presents the simulated current distributions in the ground plane of the proposed antenna at 5 GHz. As shown in Fig. 5 (b), at the second resonance frequency, the current flows are more dominant around of the L-shaped slit structures.

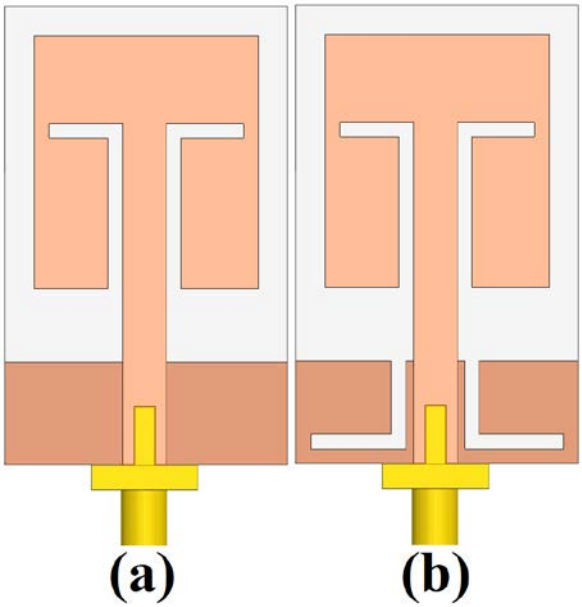

FIG.2. (A) ORDINARY ANTENNA WITH TWO INVERTED L-SHAPED SLITS IN THE RADIATING PATCH, (B) THE PROPOSED ANTENNA.

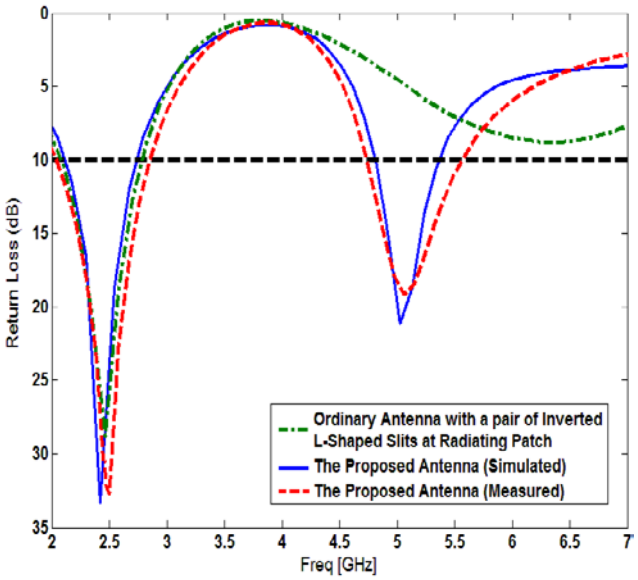

FIG.3. SIMULATED RETURN LOSS CHARACTERITICS FOR THE MONOPOLE ANTENNAS SHOWN IN FIG. 2.

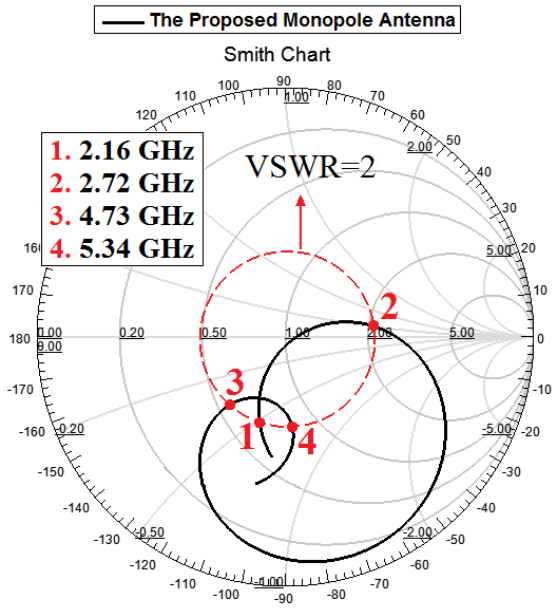

FIG. 4. SMITH CHART DEMONSTRATION OF THE SIMULATED INPUT IMPEDANCE FOR THE PROPOSED ANTENNA.

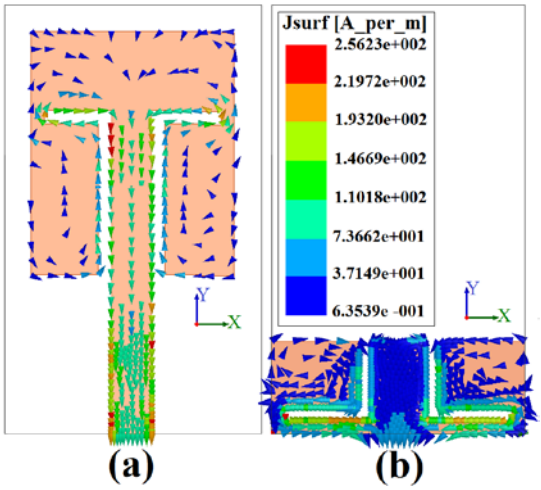

FIG. 5. SIMULATED SURFACE CURRENT DISTRIBUTIONS FOR THE PROPOSED ANTENNA, (A) ON THE RADIATING PATCH AT 2.4 GHZ, (B) IN THE GROUND PLANE AT 5 GHZ.

The proposed antenna with optimal design was built and tested. The fabricated antenna has a frequency band from 2.05 GHz to 2.76 GHz and 4.6 GHz to 5.46 GHz. As shown in Fig. 3, there has a discrepancy between measured data and the simulated results. Fig. 6 illustrates the measured radiation patterns, including the Co-polarization and cross-polarization, in the H–plane (x-z plane) and E-plane (y-z plane). It can be seen that the radiation patterns in *x-z* plane are nearly omni-directional for the two frequencies. Figure 7 shows the measured maximum gain of the proposed antenna for the Wi-Fi frequencies. As shown in Fig. 7, the maximum gain of the proposed antenna has a variation similar to other monopole antennas for these frequencies.

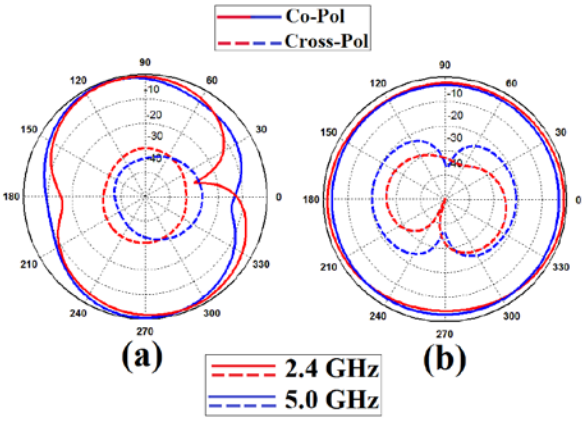

FIG. 6. MEASURED RADIATION PATTERNS OF THE PROPOSED ANTENNA, (A) 2.4 GHZ, AND (B) 5 GHZ.

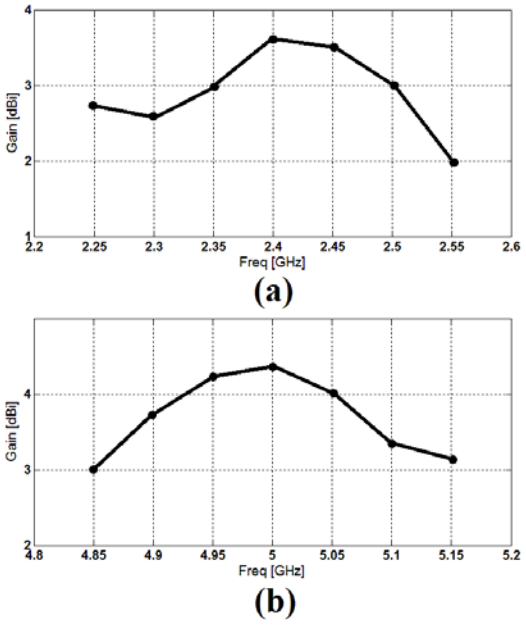

FIG.7. MEASURED GAIN FOR THE PROPOSED ANTENNA AT 2.4 GHZ AND 5 GHZ

Conclusions

A new monopole antenna with dual band operation has been presented. The proposed antenna can operate from 2.05 GHz to 2.76 GHz and 4.6 GHz to 5.46 GHz for Wireless Fidelity(Wi-Fi) applications. To generate a dual band function, a pair of inverted L-shaped slits at radiating patch and a pair of L-shaped slits in the ground plane were utilized. The proposed antenna has a good antenna gains and radiation behavior within the 2.4 GHz and 5 GHz frequencies. Simulated and experimental results show that the proposed antenna could be a good candidate for Wi-Fi systems in a small size.

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